DOCUMENT RESUME

ED 208 012 TM 810 698

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TITLE Regression Study of Learner Control Data.
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SPONS AGENCY National Science Foundation, Washington, D.C.
PUB DATE Aug 78
GRANT SED-76-1650
NOTE 28p.

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Higher Education; Mathematical Concepts; *Pretests Posttests; *Regression (Statistics); *Scores; Student Participation; Student Responsibility; *Teaching Methods
IDENTIFIERS *Learner Control

ABSTRACT

Data from three separate experiments were employed. College undergraduates were taught laws of logarithms by means of the same lesson material, and received the same twenty-item posttest after they were instructed under one of three learner control conditions. In the complete learner control condition, students chose both the sequence and number of primary presentation forms displayed to them. In the partial learner control condition, students chose how many instances were displayed to them. In the no learner control condition, students received a fixed sequence and number of primary presentation forms. Stepwise and all possible regressions routines were run using six basic presentation characteristics and various combinations, powers, and interactions of these as predictors of student posttest performance. There were no significant posttest score differences between the three learner control conditions. The predictive equations produced for the data of each learner control condition were similar to one another, but, the models produced for the complete learner control and no learner control data accounted for more of the posttest score variance than the predictive models produced for the partial learner control and combined data. Minimal posttest score variance was accounted for by any of the predictive equations that were investigated. (Author/GK)

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Regression Study of Learner Control Data[1]

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August, 1978

TM 810 698

[1]This research was supported in part by Grant No. SED 76-1650 from the National Science Foundation.

Abstract

Data from three separate experiments were employed. The 189 college undergraduates in these experiments were taught laws of logarithms by means of the same lesson material. The students also received the same twenty-item posttest after they were instructed under one of three learner control conditions. In the complete learner control condition, students were able to choose both the sequence and number of primary presentation forms displayed to them. In the partial learner control condition, students only were able to choose how many instances were displayed to them. In the no learner control condition, students received a fixed sequence and number of primary presentation forms. Stepwise and all possible regressions routines were run using six basic presentation characteristics and various combinations, powers, and interactions of these characteristics as predictors of student posttest performance. There were no significant posttest score differences between the three learner control conditions. The predictive equations produced for the data of each learner control condition were similar to one another. But, the predictive models produced for the complete learner

control and no learner control data accounted for more of the posttest score variance than the predictive models produced for the partial learner control and combined data. Very little of the posttest score variance was accounted for by any of the predictive equations that were investigated.

Regression Study of Learner Control Data

The purpose of this study was to invesitgate 1) how certain presentation characteristics relate to posttest performance on a rule-using task, and 2) whether these relationships change under different learner control treatment conditions.

A rule (generality) describes a relationship between concepts, events, or symbols. In this study, the rules were four mathematical laws of logarithms. An instance of a rule may be in the form of an example or a practice item. An example presents how the rule is applied to specific information. A practice item asks the student to apply the rule to given information. Merrill and Wood (1976) refer to rules, examples, and practice problems as primary presentation forms.

Presentation characteristics are variations in the way that information is conveyed by instruction. The six presentation characteristics included in this study were amount of time rules were displayed, amount of time examples were displayed, amount of time practice problem were displayed, number of times the rules were displayed, number of examples displayed, and number of practice items displayed.

It was hypothesized that whether or not students were permitted to choose the number and/or sequence of primary presentation forms they received would affect the relationships between the presentation characteristics and student posttest performance.

Method

Data from three separate experiments were employed in this study (Strickland, Fletcher & Merrill, 1978; Walker & Merrill, 1978; Wilcox, Richards, Christensen, Rosenvall, & Merrill, 1978).

Students. In each of these experiments, the participants were student volunteers enrolled in an introductory algebra course at Brigham Young University. There were 189 students altogether.

Materials. The rule-using task in all three experiments was to compute common logarithms by using the laws of common logarithms. These laws are:

1. $\log 10^x = x$
2. $\log (x \cdot y) = \log x + \log y$
3. $\log (xp) = p \log x$
4. $\log (x/y) = \log x - \log y$

The three experiments used the same lesson to teach the rule-using task. This lesson consisted of five segments. The instructional objectives of these segments appear in Figure 1.

Insert Figure 1 about here

Each segment was composed of a rule, examples of the rule, and practice items of the rule. Figure 2 shows the rule, one example, and one practice item for segment three.

Insert Figure 2 about here

All three experiments employed a posttest containing twenty logarithm problems which paralleled the practice problems in the lesson.

Presentation characteristics. The six basic presentation characteristics were amount of time rules were displayed (TR), amount of time examples were displayed (TE), amount of time practice items were displayed (TP), number of times the rules were displayed (NR), number of examples displayed (NE), and number of practice items displayed (NP). Many other variables were generated from these basic presentation characteristics. The basic presentation characteristics and generated variables were divided into four groups in such a way that no variables within a group were linearly

dependent. Figure 3 lists the variables in each of the four groups and describes how the basic presentation characteristic variables were transformed to become the generated variables.

Insert Figure 3 about here

Levels of learner control. There were three learner control conditions in which the students learned the rule-using task. In the complete learner control condition, students were able to choose both the sequence and number of primary presentation forms which were displayed to them. In the partial learner control condition, students were able to choose how many instances to study. But, they had no control over the sequence of primary presentation forms. In the no learner control condition, students received a fixed number and sequence of primary presentation forms.

Data analysis. Posttest score was used as the dependent variable in every analysis. Two all possible regressions routines were run using group two, group three, and group four variables respectively as the independent variables on

both the separate data of each of the three learner control conditions and the combined data of all the conditions. One all possible regression routine used Mallow's C_p as the criterion for selection. The other used adjusted R^2 (R^2_a) as the criterion for selection. Because of the large number of variables in group one, a stepwise regression routine, which included as independent variables the variables in group one, was conducted on the combined data of all the learner control conditions. TPNP was the only variable to enter the prediction equation when the lower limit of the F to enter was set at four. Ten of the remaining variables with the largest F to enter values then were used along with TPNP as independent variables in the two all possible regressions routines run on the separate data of each of the learner control conditions. Finally, a regression which included two indicator variables designating the learner control condition students belonged to was performed on the combined data to test for learner control treatment differences. Then, the "best" set of predictor variables[1] for posttest scores of all the students was tested to determine whether these variables could be used as covariates. Because levels of learner control did not interact with these independent variables, they were added to the regression equation as covariates to discover whether removal of the

posttest variance associated with this "best" set of predictors would enable the learner control treatment differences to become significant.

Results

Table 1 presents the predictors, R^2 value, F value, and level of significance of the predictive models that were obtained from the all possible regression analyses. None of the predictive equations for group two variables and group three variables were significant. For group one variables, the predictive equation for complete learner control data was $Y = 13.63 + .0059\ TPNP + .0000179\ TR^2NE^2 - .000515\ TE^2NP$. The C_p and R_a^2 criteria yielded different models for the no learner control data. The C_p criterion produced the model $Y = 24.35 - 1.63\ NR - .139\ TENR + .024\ TENP$ while the R_a^2 criterion produced the model $Y = 31.85 - 3.27\ NR - .081\ TRTE + .053\ TENP - .0083\ TPNP - .076\ TE^2 + .0064\ TE^2TR$. For group four variables, the predictive equation for complete learner control data was $Y = 18.05 - 5.73\ EF - 6.60\ ABEF - 3.24\ ACDE + 7.04\ EFDE$. The predictive equation for partial learner control data was $Y = 18.14 - 12.43\ AB + 5.20\ ABDE$. But, the C_p and R_a^2 criterion yielded different models for the no learner control data. The C_p criterion produced the model $Y = 24.81 - 44.53\ AB + 58.59\ ABAC + 45.64\ ABEF - 52.82\ ACEF$ while the R_a^2 criterion produced the

model Y = 15.65 - 90.35 AC + 9.71 EF + 67.80 BCAC + 43.39 BCDE + 85.91 ABAC + 97.72 ABEF - 14.06 ABDE - 138.33 ACEF. Likewise, the C_p and R_a^2 criterion yielded different models for the combined data. The C_p criterion produced the model Y = 16.62 - 1.89 EF - .86 BCDE - 8.86 ABEF + 4.81 EFDE while the R_a^2 criterion produced the model Y = 15.69 + 3.64 BC - 3.48 AB - 4.74 EF + 1.74 DE - 2.93 BCDE - 5.02 ABEF + 4.75 EFDE.

Insert Table 1 about here

There were no significant posttest score differences between the three learner control conditions, F (2,186) = .244. The independent variables EF, BCDE, ABEF, and EFDE did not interact with the levels of learner control. In other words, the test for parallel slopes was non-significant, F (8,174) = .914. When the posttest variance associated with these independent variables were partialled out, the differences between the learner control conditions still remained nonsignificant, F (2,182) = .788.

Discussion

Previous learner control research failed to find significant differences in posttest score between the three

learner control conditions used in this study. Thus, the lack of significant treatment differences obtained in this study was expected.

The predictive equations produced with group two and group three variables were nearly identical for all three learner control conditions. Also, the predictive equations produced with group one and group four variables were fairly similar. Therefore, there is little indication that different learner control conditions result in different relationships between the presentation characteristics used in this study and student posttest performance.

However, the predictive models produced for complete learner control and no learner control data accounted for much more of the posttest variance than the predictive equations produced for the partial learner control and combined data. This finding does indicate that amount of learner control affects the relationship between the presentation characteristics used in this study and student posttest performance.

Good predictive models were not found. The largest R^2 of any of the predictive equations was .25 and that equation contained eight predictors. This absence of

large R^2 values suggests one or both of two possible conclusions. First, the presentation characteristics examined in this study are poor predictors. They do not closely relate to posttest performance. Second, the presentation characteristics examined in this study relate in an idiosyncratic fashion to posttest performance. In other words, the learning of one student is affected differently by the presentation characteristics than the learning of another student.

References

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Footnote

[1]The "best" set of predictor variables produced the smallest C_p value and, although it did not yield the largest R_a value, it resulted in an R_a^2 value that did not appreciably differ from the largest R_a^2 values.

Table 1

Regression

Predictors, R^2 values, F values, and level of significance of predictive models obtained from two methods of an all possible regression routine

Method	Condition: Complete Learner Control n = 65	Partial Learner Control n = 60	No Learner Control n = 64	All Data Combined n = 189
		Group 1 Variables		
C_p				
Best set of predictors	TPNP, TR^2NE^2, TE^2NP	TR^2NE^2	NR,TENR,TENP	
R^2	.15	.02	.15	
F	3.61 (3,61)	.99 (1,58)	3.47 (3,60)	
F	.0182	.3247	.0216	
R_a^2				
Best set of predictors	TPNP,TR^2NE^2, TE^2NP	TENR,TR^2NE^2	NR,TRTE,TENP, TPNP,TE^2,TE^2TR	
R^2	.15	.04	.21	
F	3.61 (3,61)	1.29 (2,57)	2.59 (6,57)	
F	.0182	.2828	.0273	
		Group 2 Variables		
C_p				
Best set of predictors	TTTN	TTTN	TT,TTTN	TT^2TN^2TN
R^2	.04	.008	.05	.02
F	2.49 (1,63)	.45 (1,58)	1.68 (2,61)	3.50 (1,187)
F	.1193	.5045	.1956	.0628

Table 1
(Continued)

R_a				
Best set of predictors	TTTN	TTTN	TT,TTTN	TT^2TT,TN^2TT^2TI P4
R^2	.04	.008	.05	.03
F	2.49 (1,63)	.45 (1,58)	1.68 (2,61)	1.98 (3,185)
F	.1193	.5045	.1956	.1186
	Group 3 Variables			
C_p				
Best set of predictors	NI	TINI	TI,NI^2	NI
R^2	.04	.008	.05	.02
F	2.51 (1.63)	.44 (1,58)	1.69 (2,61)	3.45 (1,187)
F	.1185	.5087	.1939	.06
R_a^2				
Best set of predictors	NI, NI^2	TI,TINI	TI,NI^2	NI,TI^2, TI^2TINI
R^2	.06	.04	.05	.03
F	1.88 (2,62)	1.04 (2,57)	1.69 (2,61)	2.16 (3,185)
F	.1611	.3617	.1939	.0937
	Group 4 Variables			
C_p				
Best set of predictors	EF,ABEF,ACDE, EFDE	AB,ABDE	AB,ABAC,ABEF, ACEF	EF,BCDE, ABEF,EFDE

Table 1

(Continued)

R^2	.23	.10	.18	.09
F	4.59 (4,60)	3.24 (2,57)	3.26 (4,59)	4.32 (4,184)
F	.0027	.0463	.0176	.0023
$\bar{R}^2_a$				
Best set of predictors	EF,ABEF,ACDE EFDE	AB,ABDE	AC,EF,BCAC,BCDE, ABAC,ABEF,ABDE, ACEF	BC,AB,EF, DE,BCDE, ABEF,EFDE
R^2	.23	.10	.25	.11
F	4.59 (4,60)	3.24 (2,57)	2.26 (8,55)	3.09 (7,181)
F	.0027	.0463	.0362	.0042

Segment	**1**	Compute common logarithms by using the Laws of Common Logarithms.
Segment	**2**	Given log m and log n, find log m/n.
Segment	**3**	Given log b, find log b^p for any real exponent p.
Segment	**4**	Given log x and log y, find log xy.
Segment	**5**	Given a power of 10, find its common logarithm. Also, given the common logarithm of a number a, write a as a power of 10.

Figure 1. Instructional objectives of each segment of instruction.

RULE Logarithm of a Power

If x and b are real numbers, and $b > 0$,

then $\log b^x = x \cdot \log b$.

The proof is as follows:

If $\log b = p$

then $b = 10^p$

$b^x = (10^p)^x$

$= 10^{xp}$

so $\log b^x = \log 10^{xp}$

$= xp$

$= x \log b$

EXAMPLE

What is log 243?

Given: $243 = 3^5$ $\log 3 = .4771$

$\log 3^5 = 5 \log 3$

$= 5(.4771)$

$\log 243 = 2.3855$

PRACTICE

What is log 343?

Given: $343 = 7^3$ $\log 7 = .8451$

Feedback

What is log 343?

Given: $343 = 7^3$ $\log 7 = .8451$

$\log 7^3 = 3 \log 7$

$= 3(.8451)$

$\log 343 = 2.5353$

(student response)

Figure 2. The rule, one example, and one practice of instruction.

GROUP ONE VARIABLES

Original Variables

1. Time on rule displays - TR
2. Time on example displays - TE
3. Time on practice displays - TP
4. Number of times rules shown - NR
5. Number of examples - NE
6. Number of practice items - NP

Generated Variables

7. $TR \cdot TR = TR^2$
8. $TE \cdot TE = TE^2$
9. $TP \cdot TP = TP^2$
10. $NR \cdot NR = NR^2$
11. $NE \cdot NE = NE^2$
12. $NP \cdot NP = NP^2$
13. $TR \cdot TE = TRTE$
14. $TR \cdot TP = TRTP$
15. $TR \cdot NR = TRNR$
16. $TR \cdot NE = TRNE$
17. $TR \cdot NP = TRNP$
18. $TE \cdot TP = TETP$
19. $TE \cdot NR = TENR$
20. $TE \cdot NE = TENE$
21. $TE \cdot NP = TENP$
22. $TP \cdot NR = TRNR$
23. $TP \cdot NE = TPNE$
24. $TP \cdot NP = TPNP$
25. $NR \cdot NE = NRNE$
26. $NR \cdot NP = NRNP$
27. $NE \cdot NP = NENP$
28. $TR \cdot TR \cdot TR = TR^2TR$
29. $TR \cdot TR \cdot TR = TR^2TE$
30. $TR \cdot TR \cdot TP = TR^2TP$
31. $TR \cdot TR \cdot NR = TR^2NR$
32. $TR \cdot TR \cdot NE = TR^2NE$
33. $TR \cdot TR \cdot NP = TR^2NP$
34. $TE \cdot TE \cdot TR = TE^2TR$
35. $TE \cdot TE \cdot TE = TE^2TE$
36. $TE \cdot TE \cdot TP = TE^2TP$
37. $TE \cdot TE \cdot NR = TE^2NR$
38. $TE \cdot TE \cdot NE = TE^2NE$
39. $TE \cdot TE \cdot NP = TE^2NP$
40. $TP \cdot TP \cdot TR = TP^2TR$
41. $TP \cdot TP \cdot TE = TP^2TE$
42. $TP \cdot TP \cdot TP = TP^2TP$
43. $TP \cdot TP \cdot NR = TP^2NR$
44. $TP \cdot TP \cdot NE = TP^2NE$
45. $TP \cdot TP \cdot NP = TP^2NP$
46. $NR \cdot NR \cdot TR = NR^2TR$
47. $NR \cdot NR \cdot TE = NR^2TE$
48. $NR \cdot NR \cdot TP = NR^2TP$
49. $NR \cdot NR \cdot NR = NR^2NR$
50. $NR \cdot NR \cdot NE = NR^2NE$
51. $NR \cdot NR \cdot NP = NR^2NP$
52. $NE \cdot NE \cdot TR = NE^2TR$
53. $NE \cdot NE \cdot TE = NE^2TE$
54. $NE \cdot NE \cdot TP = NE^2TP$
55. $NE \cdot NE \cdot NR = NE^2NR$
56. $NE \cdot NE \cdot NE = NE^2NE$
57. $NE \cdot NE \cdot NP = NE^2NP$
58. $NP \cdot NP \cdot TR = NP^2TR$
59. $NP \cdot NP \cdot TE = NP^2TE$
60. $NP \cdot NP \cdot TP = NP^2TP$
61. $NP \cdot NP \cdot NR = NP^2NR$
62. $NP \cdot NP \cdot NE = NP^2NE$
63. $NP \cdot NP \cdot NP = NP^2NP$
64. $TR \cdot TR \cdot TE \cdot TE = TR^2TE^2$
65. $TR \cdot TR \cdot TP \cdot TP = TR^2TP^2$
66. $TR \cdot TR \cdot NR \cdot NR = TR^2NR^2$
67. $TR \cdot TR \cdot NE \cdot NE = TR^2NE^2$
68. $TR \cdot TR \cdot NP \cdot NP = TR^2NP^2$
69. $TE \cdot TE \cdot TP \cdot TP = TE^2TP^2$
70. $TE \cdot TE \cdot NR \cdot NR = TE^2NR^2$
71. $TE \cdot TE \cdot NE \cdot NE = TE^2NE^2$
72. $TE \cdot TE \cdot NP \cdot NP = TE^2NP^2$
73. $TP \cdot TP \cdot NR \cdot NR = TP^2NR^2$
74. $TP \cdot TP \cdot NE \cdot NE = TP^2NE^2$
75. $TP \cdot TP \cdot NP \cdot NP = TP^2NP^2$
76. $NR \cdot NR \cdot NE \cdot NE = NR^2NE^2$
77. $NR \cdot NR \cdot NP \cdot NP = NR^2NP^2$
78. $NE \cdot NE \cdot NP \cdot NP = NE^2NP^2$

Figure 3. The independent variables used in the stepwise and all possible regressions routines.

GROUP TWO VARIABLES

1. $TR + TE + TP = TT$
2. $NR + NE + NP = TN$
3. $TT \cdot TT = TT^2$
4. $TN \cdot TN = TN^2$
5. $TT \cdot TN = TTTN$
6. $TT \cdot TT \cdot TT = TT^2TT$
7. $TT \cdot TT \cdot TN = TT^2TN$
8. $TN \cdot TN \cdot TT = TN^2TT$
9. $TN \cdot TN \cdot TN = TN^2TN$
10. $TT \cdot TT \cdot TN \cdot TN = TT^2TN^2$
11. $TT \cdot TT \cdot TT \cdot TN = TT^2TTTN$
12. $TT \cdot TT \cdot TN \cdot TN \cdot TN = TT^2TN^2TN$
13. $TN \cdot TN \cdot TN \cdot TT = TN^2TNTT$
14. $TN \cdot TN \cdot TT \cdot TT \cdot TT = TN^2TT^2TT$
15. $TT \cdot TT \cdot TT \cdot TN \cdot TN \cdot TN = P4$

GROUP THREE VARIABLES

1. $TE + TP = TI$
2. $NE + NP = NI$
3. $TI \cdot TI = TI^2$
4. $NI \cdot NI = NI^2$
5. $TI \cdot NI = TINI$
6. $TI \cdot TI \cdot TI = TI^2TI$
7. $TI \cdot TI \cdot NI = TI^2NI$
8. $NI \cdot NI \cdot TI = NI^2TI$
9. $NI \cdot NI \cdot NI = NI^2NI$
10. $TI \cdot TI \cdot NI \cdot NI = TI^2NI^2$
11. $TI \cdot TI \cdot TI \cdot NI = TI^2TINI$
12. $TI \cdot TI \cdot NI \cdot NI \cdot NI = TI^2NI^2NI$
13. $NI \cdot NI \cdot NI \cdot TI = NI^2NITI$
14. $NI \cdot NI \cdot TI \cdot TI \cdot TT = NI^2TI^2TI$
15. $TI \cdot TI \cdot TI \cdot NI \cdot NI \cdot NI = P5$

GROUP FOUR VARIABLES

1. $NE + NP = BC$
2. $NR + NE = AB$
3. $NR + NP = AC$
4. $TE + TP = EF$
5. $TR + TE = DE$
6. $TR + TP = DF$
7. $BC \cdot AB = BCAB$
8. $BC \cdot AC = BCAC$
9. $BC \cdot EF = BCEF$
10. $BC \cdot DE = BCDE$
11. $BC \cdot DF = BCDF$
12. $AB \cdot AC = ABAC$
13. $AB \cdot EF = ABEF$
14. $AB \cdot DE = ABDE$
15. $AB \cdot DF = ABDF$
16. $AC \cdot EF = ACEF$
17. $AC \cdot DE = ACDE$
18. $AC \cdot DF = ACDF$
19. $EF \cdot DE = EFDE$
20. $EF \cdot DF = EFDF$
21. $DE \cdot DF = DEDF$

Figure 3. Continued

Figure Captions

Figure 1. Instructional objectives of each segment of instruction.

Figure 2. The rule, one example, and one practice item for segment three.

Figure 3. The independent variables used in the stepwise and all possible regressions routines.